at all? Have they, since the earth settled down after Archæan times, been brought up in any appreciable quantity from great depths, or are we now dependent on the mere lateral segregation of small traces originally scattered residually through the outermost crust and left as the result of an imperfect gravitational adjustment when the earth passed from the molten to the solid state?"

Of the two rival theories, namely (1) that the metals have been brought from great depths in igneous eruptives, and (2) that the metalliferous deposits have been formed by the segregation of materials originally disseminated through comparatively superficial rocks, he remarks that they need not be mutually exclusive, and that they may be complementary; but after a consideration of the relative significance and merits of the two theories, he infers that only a small fraction of ore deposits show signs of transport from great depths, while the majority of those that are workable seem to be the result of simple lateral segregation, and even a large proportion of these are probably derived by segregation processes in the uppermost layers.

This view, which is probably the truth of the matter, so far as can be judged from the geodynamical evidence at present available, has an important bearing on the problem of the duration of supplies of metals. Supplies of lead, tin, zinc, and copper are likely to be exhausted long before those of coal and iron, and Sir Thomas Holland thinks it unjustifiable to take an optimistic view of the possibilities as regards aluminium, for bauxite deposits are few and small, and it remains to be proved that the metallurgical treatment of aluminium silicates is economically feasible.

In the concluding portion of his address he made some interesting remarks on the present condition of geology as a science. He clearly agrees with the editor of the New York *Engineering and Mining Journal-Press*, who told us recently that geological science is in the doldrums. Geological science, says Sir Thomas, is at present experiencing "a reposeful interlude"; it is indulging a "siesta." In his opinion the geological imago is more likely to emerge from its chrysalis stage at the meetings of the Institution of Mining and Metallurgy than at the meetings of the Geological Society. It would perhaps be wiser to expect any development that may affect geology as a science to be less sudden and spectacular than the emergence of an imago. The development is more likely to be gradual. Nothing could contribute more effectively towards the desired change than regular and joint meetings for discussion by the various societies interested. Is it too much to expect that the Geological Society, the Mineralogical Society, and the Institution of Mining and Metallurgy will one day establish permanent joint sessions and meet periodically, even if infrequently, to discuss topics of common interest? There is much uncultivated common ground between them. Dynamical geology, petrology, and mineral genetics require to be welded together into a scientific whole. By meeting periodically to promote the attainment of this end, each of the societies concerned would, while widening its own outlook, help forward the development of science. Now or never is the time to make this move, when three such able and intimate colleagues as Sir Thomas Holland, Prof. Watts, and Dr. Evans occupy the presidential chairs of the three societies chiefly concerned.

T. C.

The Discovery of Benzene.

By Prof. JOCELYN F. THORPE, C.B.E., F.R.S.

IT is a fact not generally known that Faraday's early work at the Royal Institution was mainly of a purely chemical character and that it was not until later, about 1831, that he took up the study of electricity and magnetism, the branch of physics in which his more famous discoveries were made and with which his name is usually associated in the public mind. It is evident, of course, that this bent towards the chemical side of science was determined by his early association with Sir Humphry Davy, for Faraday has left abundant records illustrating the influence Davy's lectures and personality had on him. He seems to have first attended these lectures in 1812 when, as a youth of twenty-one, he was still serving as apprentice to Mr. George Riebau, a bookseller in Blandford Street; later he sent Davy a copy of the notes he had taken, together with a letter in which he expressed a wish to abandon trade and adopt a scientific career. It was well for posterity that this letter did not meet the same fate as that of a similar one sent to Sir Joseph Banks, then president of the Royal Society, which remained unanswered; for Davy sent a kindly and encouraging reply which not only led to an interview between them, but afterwards to the offer of a post as assistant at the Royal Institution, the salary being 25*s*. a week with the use of two rooms at the top of the house; the minute of the Managers recording this appointment is dated March 1, 1813. Faraday did not, however, remain long at the Institution, for on Sir Humphry Davy relinquishing his appointment as professor of chemistry in 1813, Faraday accompanied him as secretary during a tour through Europe which occupied the next eighteen months.

It appears that Faraday had arranged with Davy prior to the tour that his post at the Royal Institution should be kept open for him, and to this he returned in April 1815, being in the following month appointed "Assistant in the laboratory and mineralogical collection and superintendent of the apparatus at a salary of 30*s*. a week," apartments also being granted him. From this date onward until the end of what may be termed the first period, which closed with his illness in 1830, his work was almost entirely of a chemical character. His illness seems to have prevented him from doing active work for nearly four years, and thereafter he devoted his genius to the development of electricity and magnetism, and seems to have abandoned all work on the purely chemical side. Nevertheless, during the earlier period he made many important discoveries, for it seemed impossible for this versatile man to touch any branch of science without enriching it. Indeed, the initial conception of many of the principles underlying colloidal chemistry, catalysis and the diffusion of gases was due to him.

Faraday's first original work was published in the *Quarterly Journal of Science* for 1816, and dealt with the analysis of native caustic lime. His own comment on this paper, printed in his volume on "Experimental Researches on Chemistry and Physics," is interesting, for he says: "I reprint this paper at full length; it was the beginning of my communications to the public, and its results very important to me. Sir Humphry Davy gave me the analysis to make as a first attempt in chemistry, at a time when my fear was greater than my confidence, and both greater than my knowledge; at a time also when I had no thought of ever writing an original paper on science." It is interesting to note, in view of the last remark, that during the next fifteen years he published as many as sixty important scientific papers, and that nine of these appeared in the Philosophical Transactions. An examination of the records shows, moreover, that he started his experimental work immediately on entering the Royal Institution, for in a letter to Benjamin Abbott dated April 9, 1813, that is, only about a month after his appointment, he described the work he and Davy had carried out on the composition of nitrogen chloride. During these operations both investigators seem to have received injuries from the many explosions that occurred, but with characteristic tenacity they succeeded in determining the specific gravity of the liquid and several of its properties.

One of the most striking of Faraday's earlier successes was obtained in his experiments on the liquefaction of gases, for in 1823 he was able to prepare chlorine, sulphur dioxide, carbon dioxide, sulphuretted hydrogen, euchlorine and nitrous oxide in the liquid state, free from water. The experiments were carried out at some personal risk, as the apparatus used was unsuited to withstand the pressure needed. He returned to this work twenty years later, and, adding cold to pressure, obtained ammonia, sulphuretted hydrogen, and nitrous oxide in the solid state. He had hoped to liquefy oxygen, and had subjected the gas to a pressure of 60 atmospheres at a temperature of $-140°$ F. without success. It was left to his successor to achieve this end, sixty years later, in the same Institution.

In 1821 Faraday was appointed Superintendent of the House and Laboratory at the Royal Institution, although it is curious that in a letter written to R. Phillips dated May 10, 1836, he states, "In the Spring of 1823 Mr. Brande was Professor of Chemistry, Sir Humphry Davy, Honorary Professor of Chemistry, and I, Chemical Assistant in the Royal Institution." Nevertheless, it is clear from the Managers' minutes that in February 1825 he was definitely appointed "Director of the Laboratory under the superintendence of the Professor of Chemistry." It was not until 1833 that he became the first holder of the Fullerian chair of chemistry. In 1820 he published the results of a most laborious and painstaking investigation on the alloys of steel, and in 1821 he described some new compounds of carbon and chlorine. In 1824, the year in which he was elected a Fellow of the Royal Society, he undertook, at the request of a committee appointed by the president and council, an investigation into the properties of optical glass.

The year 1825 witnessed the discovery of benzene, the centenary of which is now being celebrated. It appears that the Portable Gas Company condensed oil-gas (from fish oil) at a pressure of 30 atmospheres. A thousand cubic feet of gas yielded about one gallon of liquid hydrocarbons, and from these Faraday isolated a substance he called bicarburet of hydrogen, identical with the benzene of to-day. The importance of this discovery and its effect on the work of later investigators cannot be overrated. It showed, for example, that benzene is a product of the decomposition of natural oils, and led, indirectly, to the discovery made by A. W. Hofmann twenty years later that benzene could be obtained by the distillation of coal-tar.

Probably no single discovery has had more effect on the development of the past hundred years than this, for it has led not only to the establishment of new industries in all parts of the world with the consequent employment of millions of workers, but has placed in the hands of every one materials hitherto either non-existent or obtainable only by the well-to-do. Dye-stuffs, perfumes, explosives, drugs, and similar modern commodities owe their existence to Faraday's discovery, because, once he had shown that a pure chemical substance could be produced by destructive distillation, the attention of chemists in all countries was directed to the possibility of obtaining others in the same way. Thus the isolation, in quantity, of benzene, toluene, the xylenes, naphthalene and anthracene from coal-tar was soon effected. Moreover, the influence which the discovery of the hydrocarbon had on the development of structural organic chemistry transcends that of any other substance, for benzene proved to be the keystone of "aromatic character" and the basis on which many natural products is built. The synthesis of natural indigo, to take one example of many, would have been impossible if benzene had been unknown.

It is true that Faraday had no idea whatever of the value of the discovery he had made. To him it was merely an interesting scientific fact which as soon as established ceased further to interest him. Indeed, things could not have been otherwise, because structural organic chemistry was then non-existent, and no one dreamt that there was any connexion between fish-oil and colour. But it is the pioneer who shows the way, even though he may not be able to or desirous of following it himself, and the sign-post erected by Faraday directed to a country full of rich and desirable things that could be utilised for the benefit of mankind. Fortunately, organic chemical science was served during the nineteenth century by a body of investigators who combined a clear and far-sighted vision with a manipulative skill which is the envy of their successors, and it was in their hands that Faraday's discovery was made to yield its full fruit.

In this way, therefore, one of the least of the discoveries of this great Englishman was destined to have a far-reaching effect on the civilisation of our race. Faraday, in a lecture delivered at the Royal Institution in 1816, spoke thus: "Before leaving this substance, chlorine, I will point out its history, as an answer to those who are in the habit of saying to every new fact, 'What is its use?' Dr. Franklin says to such, 'What is the use of an infant?' The answer of the experimentalist would be, 'Endeavour to make it useful.' When Scheele discovered this substance it appeared to have no use, it was in its infantine and useless state; but having grown up to maturity, witness its powers, and see what endeavours to make it useful have done." Surely nothing better than this could be said of his own discovery of benzene.

Current Topics and Events.

THE King's birthday honours list includes comparatively few names which are well known in scientific circles. Among them are the following: *Baronet*, Sir John Bland-Sutton, president of the Royal College of Surgeons; *Knight*, Prof. J. Robertson, Medical Officer of Health, Birmingham, and professor of public health in the University of Birmingham; *G.B.E.*, Sir Frederic Kenyon, Director and Principal Librarian of the British Museum; Sir John Snell, chairman of the Electricity Commission; *K.B.E.*, Dr. J. S. Flett, Director of the Geological Survey of Great Britain and the Museum of Practical Geology; *C.B.E.*, Dr. G. Rotter, Director of Explosives Research, War Office; Mr. F. A. Stockdale, Director of Agriculture, Ceylon; *O.B.E.*, Mr. W. Bevan, lately Director of Agriculture, Colony of Cyprus.

To an unsectarian gathering in connexion with the centenary meetings of the British and Foreign Unitarian Association, Lord Oxford and Asquith gave an address on "Some Phases of the History of Free Thought in the Nineteenth Century." From the contrasted lives of Robert Owen and William Cobbett, he illustrated the stimulus of free inquiry and open debate. Both men were pioneers in free and independent thinking, and Malthus was another who faced the facts careless of the hostility of his fellows. The search for truth continues to be the most imperious as well as the most stimulating of man's intellectual needs, and the form of the quest which we are accustomed to associate with the phrase "freedom of thought" is marked by independence of authority and by courageous facing of the facts wherever they may lead to in the way of conclusion. Freedom of thought marks the man of scientific temper though he may not have anything to do with what is conventionally called "science." Freedom of thought usually means the resolute exercise of scientific methods, but there is, as Lord Oxford indicated, a continual danger lest science become itself an authority that shackles freedom. Thus, he said, no greater misfortune has happened in the history of our vocabulary than that the same word "law" should be used to designate the command of a sovereign authority and the generalisations of a Newton or a Darwin. We wish that this lucid thinker had gone further in his analysis of what freedom of thought really means. Thus it is clear that, as secure scientific formulation advances, the field for freedom of thought must decrease. A formula that has stood the test of time and is verifiable by all normally constituted minds who can use the methods may be subsumed in a larger formula, but it can never be contradicted or scrapped. It is not the subject of legitimate free thought. Much of the so-called free thought of to-day is the expression of ignorance and vanity.

THE Inter-State Post-Graduate Assembly of the United States and Canada is an organisation to which nothing in Great Britain precisely corresponds. More than 500 of its members were formally welcomed in London on June 2 by the Duke of York, at the commencement of a long round of lectures and demonstrations by distinguished members of the medical profession in Great Britain. A growth of no more than nine years, the Assembly at once emphasises a need which the advance of modern scientific medicine makes more and more urgent as time goes on, and goes far towards affording the means for its satisfaction. It is significant that Dr. Charles Mayo, whose name is so closely associated with the highest specialism, should be the mouthpiece of his fellow-American visitors, of whom 65 per cent. are men in contact with the people as general practitioners, and that on several public occasions during the past week he has deplored the over-luxuriant growth of specialism in medicine and urged the importance of the "common or garden variety" of doctor. There may be many things that our hospital wards, operating theatres and laboratories can show our American visitors for their professional good; but if they turn our attention seriously to the problem of co-operation between the highly trained specialist, in theatre or laboratory, whom Dr. Mayo calls the "accumulator," and the "distributor" of medical wares, they will have done as great a service to British medicine as any we can render to them. Sir Humphry Rolleston has done well to direct attention to the urgency of the problem of post-graduate education in London. The members of the medical profession, he says, are students all their days and are naturally most anxious to keep up with the ever-advancing tide of medical knowledge. But effective means for doing this in London have yet to be thought out.

IT would be impossible to summarise here the many admirable papers read at the meetings of the Inter-State Post-Graduate Assembly. Some figures given by Colonel L. W. Harrison, of St. Thomas's Hospital, London, concerning venereal disease are, however, of general interest. Treatment during the last four years has reduced the new cases of syphilis from 42,000 to 22,000. New infections of gonorrhœa have diminished from 40,284 to 31,272. Although the number of attendances at clinics has increased, the cost has steadily diminished and in 1923–24 the estimate was 90,000*l.* less than in 1920–21, and the present cost is now 2½*d.* per head of the population.